

# Reactor Neutrino Working Group Summary

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# Reactor Neutrinos - A Tool for Discoveries

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**Reactor neutrino experiments play a central role in our understanding of neutrinos and provide a unique tool for discoveries.**

Reactor experiments probe new physics such as sterile neutrinos and neutrino magnetic moments, provide an opportunity for the first observation of coherent neutrino scattering, and advance our understanding of the 3 $\nu$  framework including precision measurements of neutrino mixing and determination of the neutrino mass hierarchy.

# Reactor Neutrinos - A Tool for Discoveries

*A flavor pure source of  $\bar{\nu}_e$*

2012 - Measurement of  $\theta_{13}$   
with Reactor Neutrinos

2008 - Precision measurement of  
 $\Delta m_{12}^2$ . Evidence for oscillation

2003 - First observation of reactor  
antineutrino disappearance



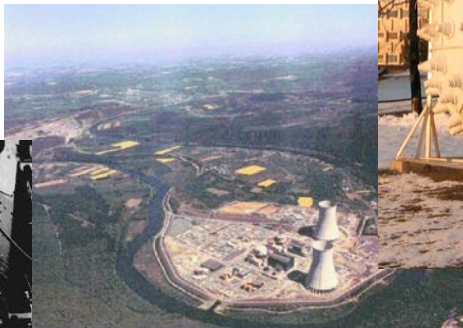
1995 - Nobel Prize to Fred  
Reines at UC Irvine

1980s & 1990s - Reactor neutrino flux  
measurements in U.S. and Europe

1956 - First observation  
of (anti)neutrinos



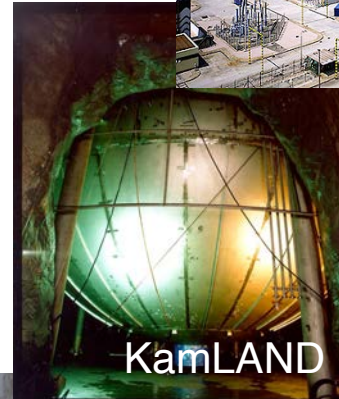
Savannah River



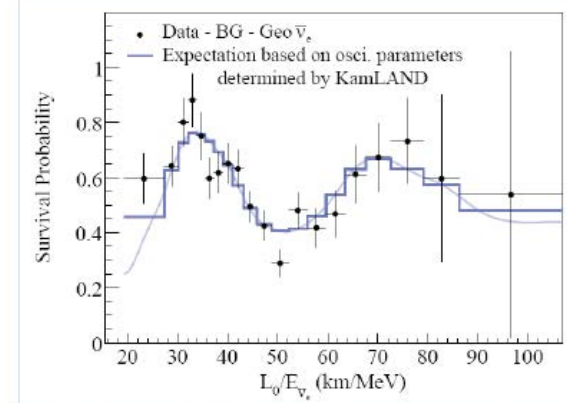
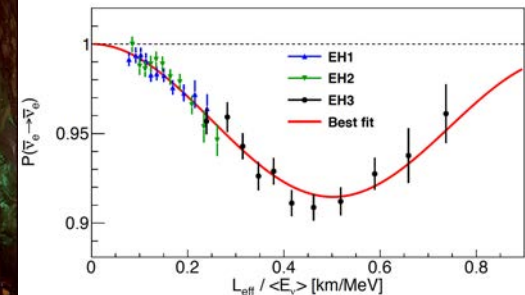
Chooz



Daya Bay  
Double Chooz  
RENO



KamLAND



55 years of liquid scintillator detectors  
a story of varying baselines...

# Short-Baseline Reactor Experiment

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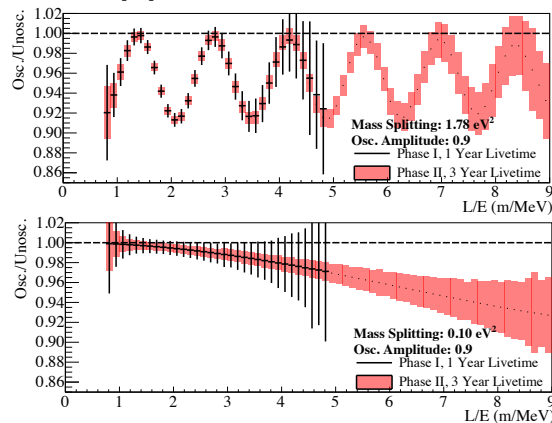
**A short-baseline experiment designed to resolve the reactor neutrino anomaly through oscillation and spectral measurements has the potential to discover new physics and is the highest priority of this working group.**

Timely execution is critical. Short-baseline reactor disappearance experiments are complementary to the FNAL short-baseline program focusing on appearance measurements. Given the US experience and facilities, there is an opportunity for the US to lead and host a short-baseline reactor experiment. Proposed projects are ready to proceed and provide an opportunity for high-impact science in the next three to five years. They fit the scope and cost of the small-scale program and offer opportunities for international collaboration.

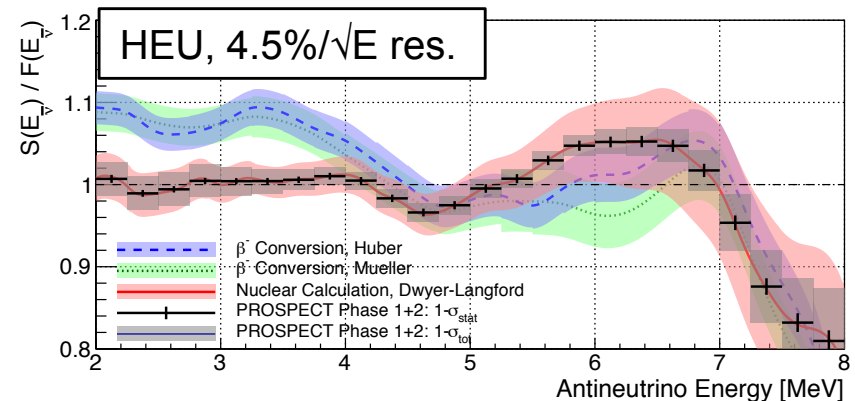
# Short-Baseline Reactor Experiment



## $\bar{\nu}_e$ Disappearance Oscillation Search

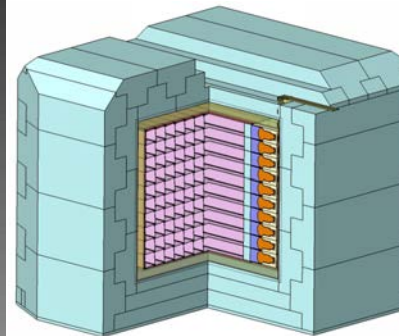
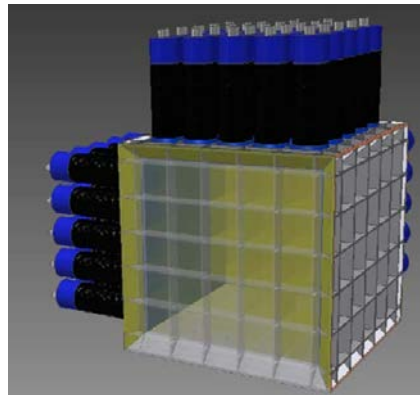
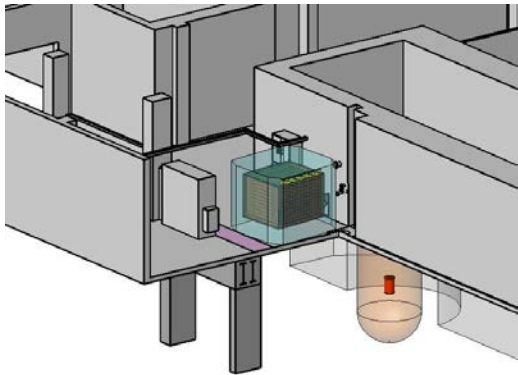


## Spectral Measurement



Complementary to FNAL short-baseline program. Addresses reactor anomaly.  
Discovery potential at modest cost.

Multiple locations available. Multiple technologies proposed. Prototypes exist.



Experiments ready to proceed. US can lead and host such an experiment.

# Medium-Baseline Reactor Experiment

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**Medium-baseline experiments provide opportunities to determine the neutrino mass hierarchy without the matter effect and precision measurements of  $\theta_{12}$ ,  $\Delta m^2_{21}$ , and  $\Delta m^2_{32}$ . Near-term R&D can inform a potential contribution overseas and ensures US involvement in the determination of the mass hierarchy.**

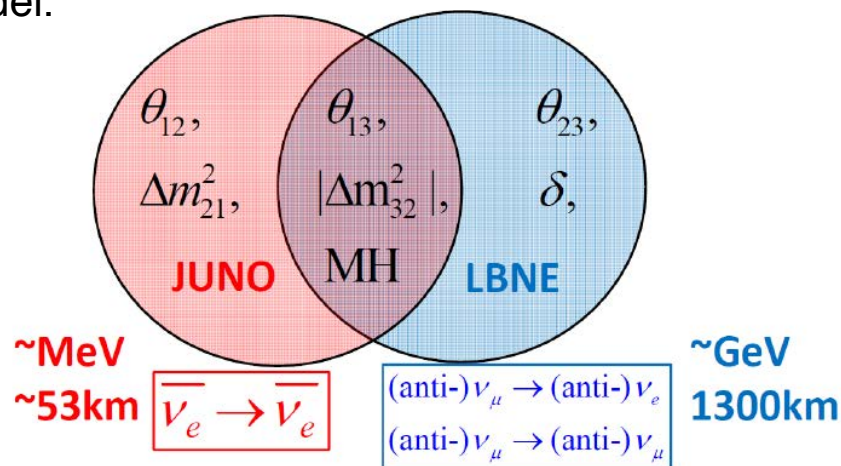
Such an experiment is complementary to accelerator-based long-baseline experiments and provides critical tests of the three-neutrino framework.



# Medium-Baseline Reactor Experiment



MBRE & LBNE are complementary and will measure all aspects of neutrino mixing in the 3-v Standard Model. Comparison of  $\theta_{13}$  from Daya Bay and LBNE will give us the best test of the 3v model.

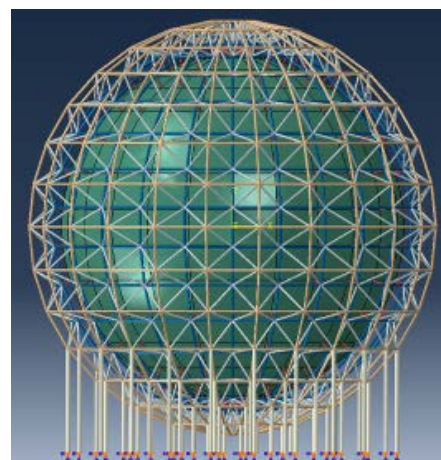


	JUNO	LBNE
$\sin^2 2\theta_{12}$	0.7%	
$\Delta m^2_{21}$	0.6%	
$ \Delta m^2_{32} $	0.5%	0.3%
MH	3-4 $\sigma^{**}$	>5 $\sigma$
$\sin^2 2\theta_{13}$	14%*	3%
$\sin^2 \theta_{23}$		3%
$\delta_{CP}$		10°

\* Daya Bay reaches 3%

\*\* 4 $\sigma$  requires 1%  $|\Delta m^2_{\mu\tau}|$

Opportunity to continue  
US-China collaboration.

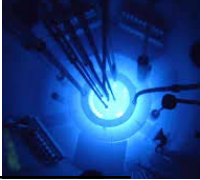


R&D required to define  
US contribution.



# Applied Reactor Neutrino Physics

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**Measurements of reactor neutrinos are also relevant to the nuclear physics and applied reactor safeguards communities.**

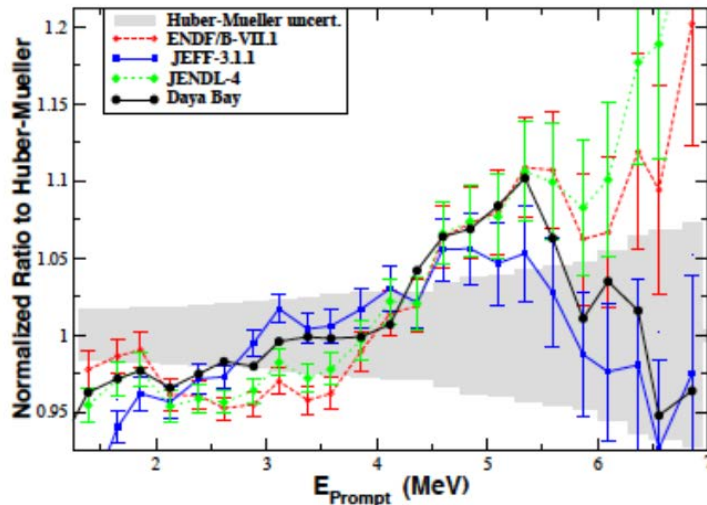
Many of the theoretical and experimental challenges are common across these fields, and reactor neutrino measurements have the potential to uniquely inform these communities.



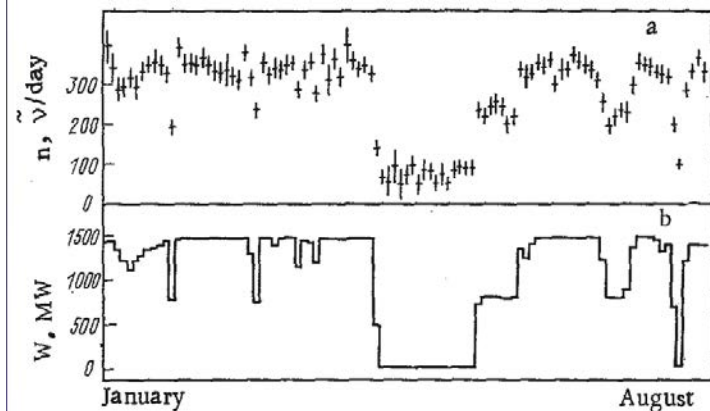
# Applied Reactor Neutrino Physics



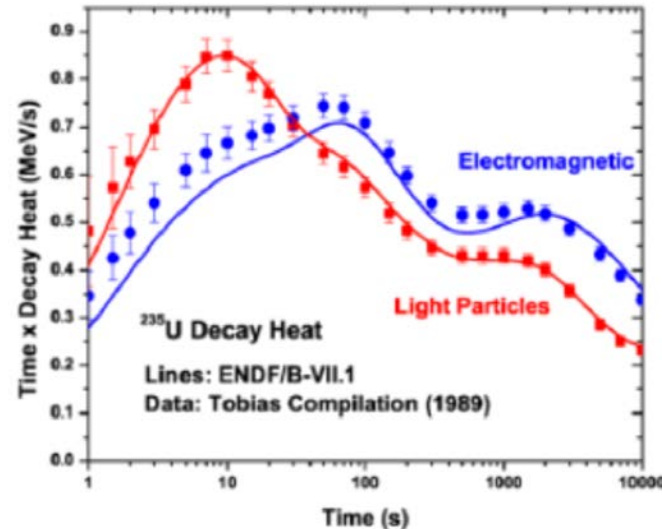
## Understanding Reactor Spectra



## Reactor Monitoring



## Fission Yields, Decay Heat Studies



## Fuel Diversion Studies



Need to understand antineutrino flux and spectra from reactors